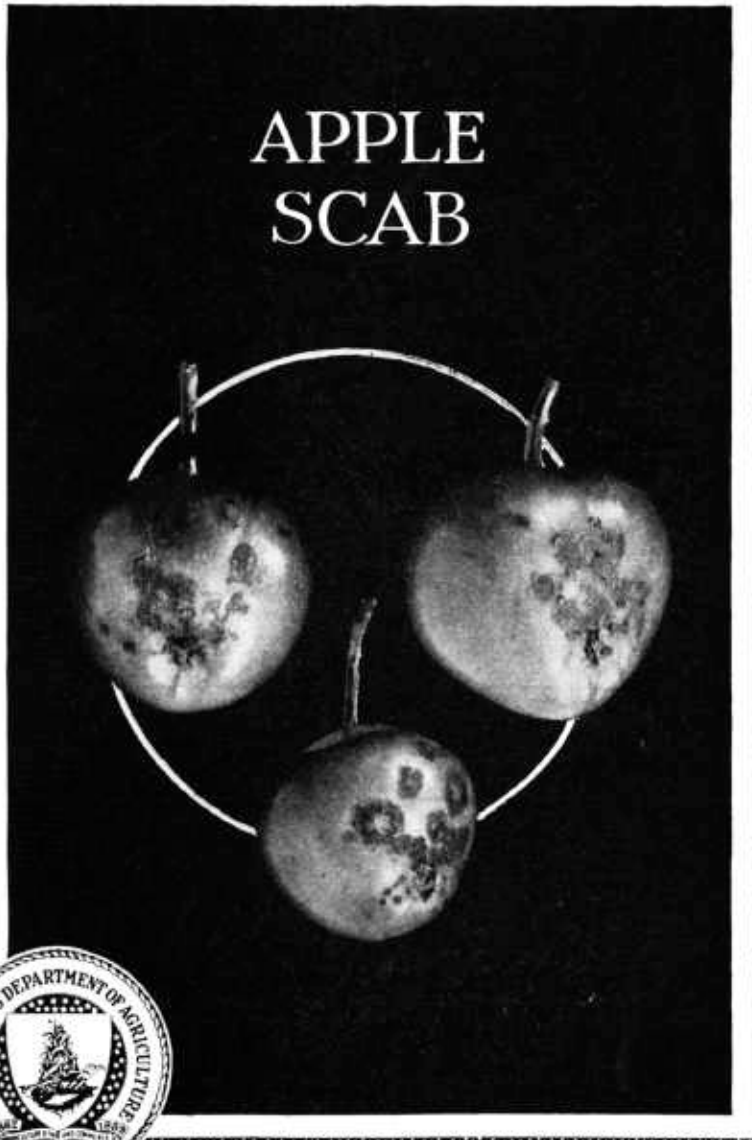
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1478

APPLE SCAB



APPLE SCAB is a disease which causes heavy losses in most sections of the United States in which apples are grown. Fruit, leaves, blossoms, and occasionally twigs are affected.

Injury to the fruit may render it a total loss. Injury to the leaves may result in premature defoliation, which greatly weakens the trees.

The life history of the fungus causing apple scab is given, with particular reference to control measures.

The relative susceptibility of the principal commercial apple varieties to the disease is shown.

Directions for spraying and for the making of dilute lime-sulphur solution and bordeaux mixture are given.

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APPLE SCAB

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ECONOMIC IMPORTANCE OF APPLE SCAB

THE DISEASE of the apple commonly known as scab [1] is one of the most destructive and most universally distributed of the diseases affecting that fruit. In seasons favorable to the development of scab, the entire crop may be destroyed or rendered unfit for market unless proper control measures have been employed. Losses of at least 50 percent of the crop are common in unsprayed orchards, and usually the remainder is unfit for market. Even in mild cases the fruit is made unsightly, and in more severe cases it is deformed, cracked, and greatly reduced in size. Its keeping quality is impaired by organisms of decay which gain entrance through the scab spots. The organism causing pink rot [2] very commonly enters in this way.

Scab is also a serious foliage disease, often causing the trees to become nearly defoliated by midsummer or a little later. Trees are often stunted by the premature loss of the leaves, which are necessary for their proper development.

Twigs may be killed by direct attacks of the scab fungus, but this phase of the disease is not common in the United States. Infection and subsequent destruction of the blossom buds or blossoms is not infrequent, especially in northern orchards. In this way the prospective crop may be reduced or entirely destroyed.

DISTRIBUTION

Scab is a disease of Old World origin and occurs practically everywhere that apples are grown. It is well distributed throughout the United States and except in certain restricted sections is a serious disease which must be combated every year. It is most destructive in the Northeastern and North-Central States, but often causes damage in the most southerly sections in which apples are grown. Even in States as far south as Arkansas and Tennessee it is common.

[1] Caused by the fungus *Venturia inaequalis* (Cke.) Winter.
[2] Caused by the fungus *Cephalothecium roseum* Cda.

DESCRIPTION

The characteristic spots on the fruit, which are familiar to most growers, give to the disease the descriptive common name "scab." The spots are usually most abundant near the calyx end of the apple (figs. 1, 2, and 3), which is the part most exposed at the time of the heaviest or early spring infections. A young spot is more or less circular in outline, dark olive in color, and presents a characteristic velvety appearance (fig. 2). An older spot is nearly circular in outline, dark gray (figs. 3 and 4) to dark brown in color (fig. 2), with a silvery overlapping border (figs. 1 and 4), which is the raised and frayed margin of the ruptured skin. Later in the season the formation of cork layers beneath the spot may cause the affected area gradually to slough away, leaving a smoother brown or gray

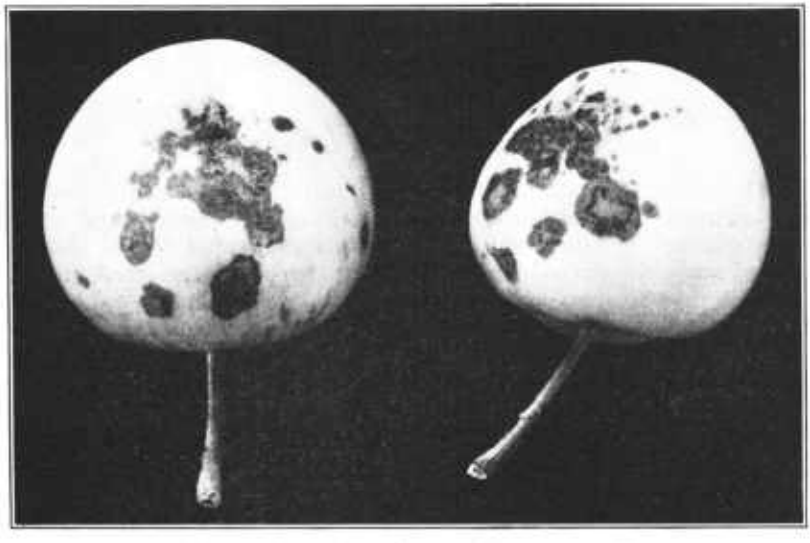

FIGURE 1.—Scab spots on deformed apples in midseason.

spot. Several spots may grow together, forming a single large spot (figs. 2 and 3). Since the normal development of the fruit is prevented, an apple with many scab spots is greatly dwarfed in size. When one side only is infected the fruit is greatly deformed (figs. 1 and 2). Scabby apples are often cracked, the cracks extending deeply into the fruit (fig. 4). The later in the season that infections occur, the less is the liability of dwarfing, deforming, and cracking the fruits.

One or both sides of the leaves may be infected (figs. 5 and 6). The infected areas may be in the form of brown or olivaceous spots (figs. 5, 6, and 7), which cause the leaf to become puckered, or they may be more diffuse, forming dark-brown indefinite moldlike patches or brown veinlike streaks over the surface. Leaves infected with scab are much more liable to be injured by sprays than are uninjured leaves.

On the blossoms and blossom buds the spots are light olive to light brown and are not always easily discerned. They occur on the pedicels (stems) and calyxes.

Twig infection either does not occur or is rare except along the coast of New England. Spots on the twigs greatly resemble those on the fruit.

LIFE HISTORY OF THE FUNGUS

In general, the fungus causing scab is to be found on or near the surface, but in the leaves it penetrates more deeply and passes the winter within their tissues. Early in the spring there are produced in those leaves lying on the ground fruiting bodies that discharge into the air spores (ascospores) which infect the young leaves, blossoms, blossom buds, and young fruit. In scab spots produced by these infections other spores (conidia) are produced in great quantities, which infect other leaves, fruits, blossoms, or blossom buds. It is important to prevent these early infections, not only to protect the parts exposed at that time but to prevent the formation of additional infection sources. In fact, so important are these secondary sources of infection that if they are abundant it is practically impossible to prevent further spread of the disease during seasons at all favorable to its development.

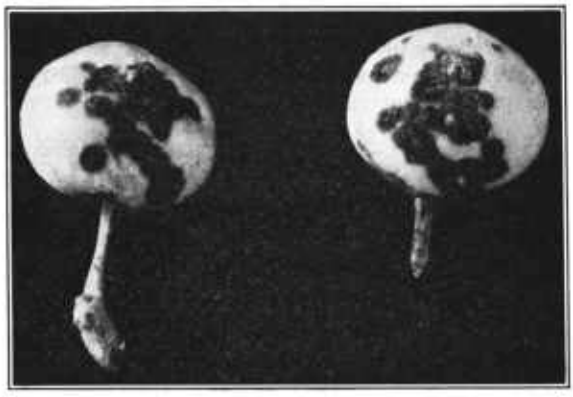

FIGURE 2.—Velvetlike scab spots on deformed young apples.

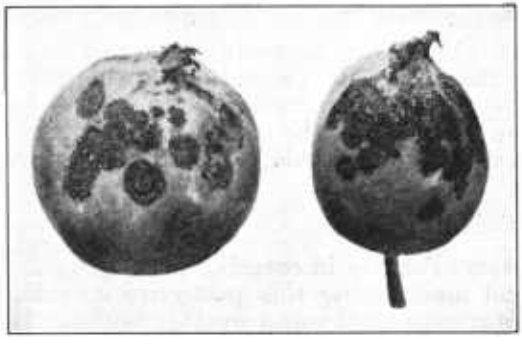

FIGURE 3.—Another type of scab on young apples

The period of heaviest infection usually ends about 4 weeks after the petals have fallen. The fungus is favored by the cool moist weather usually prevalent in the early spring. Infections rarely occur after warm weather begins. In the more northerly sections, however, new infections frequently occur during cool spells in the summer and fall, the disease sometimes developing from these infections even after the fruit is picked. In the South the disease is usually more severe at high altitudes, presumably because of the greater coolness.

Along the coast of New England especially, the fungus may pass the winter in lesions in the twigs as well as in the fallen leaves. In

that section, therefore, the control of the disease on the twigs is important, in that it eliminates another source of infection.

RELATIVE SUSCEPTIBILITY OF APPLE VARIETIES

In table 1 the more common commercial varieties are arranged in the order of their susceptibility or resistance to scab. In different seasons and in different sections the degree of apparent susceptibility varies. The fruit of the York Imperial variety, for instance, is very resistant to scab; but in moist seasons, especially at high altitudes, the crop may be very scabby. In the northern sections the Wealthy variety is often badly injured by scab, whereas in other sections it is usually considered as very resistant.

TABLE 1.—*Relative susceptibility to scab of leading apple varieties*

Very susceptible	Moderately susceptible	Moderately resistant	Very resistant
Arkansas (Mammoth Black Twig)	Akin	Baldwin	Grimes Golden
Arkansas Black	Ben Davis	Jonathan	Ingram
Delicious	Benoni	Lowland Raspberry	York Imperial
Early Harvest	Early Ripe	Maiden Blush	
Fameuse	Esopus Spitzenburg	Mann	
King David	Gano	Oldenburg	
Kinnard	Golden Delicious	Ortley	
Limbertwig	Lawver	Red Astrachan	
McIntosh	Lowry	Wagener	
Oliver Red	Northern Spy	Yellow Transparent	
Paragon	Northwestern Greening		
Red June	Ralls		
Rome Beauty	Rhode Island Greening		
Stayman Winesap	Stark		
Winesap	Summer Rambo		
Winter Banana	Tompkins King		
	Wealthy		
	Williams		
	Yellow Newtown		

PREVENTIVE MEASURES

REMOVAL OF SOURCES OF INFECTION

When practicable the removal of fallen leaves from the surface of the soil, either by gathering them from the ground or plowing them under in the fall or early spring, is a valuable aid to control by spraying. If the twigs show scab, as may be the case in New England, they should be removed, if practicable, when the trees are pruned in the winter.

SPRAYING

The principal control measure consists in covering with spray the parts liable to infection and maintaining this protective covering from the time the first leaves emerge until warm weather begins. In northern sections protection in late summer is also desirable.

With most sprays there is some risk of injury to the plant whose protection is desired. This risk is minimized by the choice of proper sprays, by using good apparatus, and especially by care on the part of the operator. It should be remembered that a spray in order to cover evenly and completely must be applied as a fine mist; otherwise it will collect in large drops. When spray is applied as a fine mist, too heavy applications are easily avoided and the risk of injury

is greatly lessened. Overspraying, with coarse streams especially, is bad practice. Such spraying may do great injury to both fruit and foliage, and, if the application comes directly after the petals have fallen, may prevent a proper setting of fruit by killing the flowers as they are beginning their development into fruits. Those who use spray guns should take particular care to avoid overspraying.

Poor results in spraying are often due to the fact that the trees need pruning. It is difficult and often impossible to spray thoroughly thick bushy trees, because the spray must strike and cover the parts to be protected. Trees which are properly opened by pruning and have proper spacing between the branches can be more readily covered throughout with spray.

The spray should consist of lime-sulphur solution (33° to 34° Baumé) diluted at the rate of 1¼ gallons to 50 gallons of water.

In the first three applications arsenate of lead, 1 pound of the powder or 2 pounds of the paste, should be added for the control of insect pests.[3] Where arsenate of lead is used it will be necessary for the grower to be prepared to wash the fruit at harvest time if lead arsenate is present in the residue in amounts that would be dangerous to the public health. Fruit containing lead or arsenic residues in amounts dangerous to the consuming public should be washed before being offered for sale. Directions for washing fruits to remove spray may be obtained from State agricultural experiment stations and the United States Department of Agriculture.

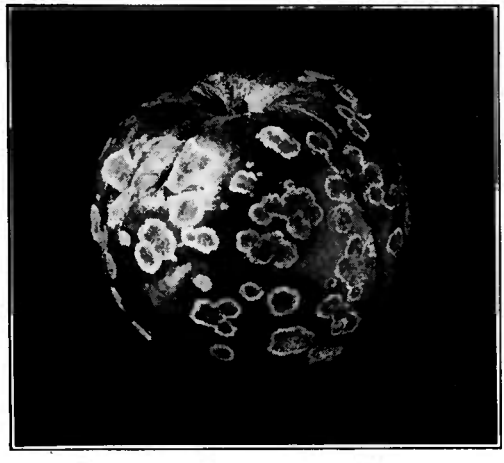

FIGURE 4.—Scab on a mature apple. Note the cracks.

The following schedule of spray applications has stood the test of many years with but slight modifications.

FIRST APPLICATION

Directly after the blossom-cluster buds have opened, the first application should be made. If the blossom buds themselves have not opened when the application is completed, and especially if the weather is cool and moist, it is desirable to make another application almost immediately.[4] In many years, however, the commercial grower has not time to make more than one application at this time. In the North this application is nearly always the most important one. In the South the application directly after the petals have fallen is often more important.

[3] For specific directions write to the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

[4] In the northern United States many experimenters have stressed the importance of 2 sprays at this time, the first being called the "prepink" and the second the "pink."

SECOND APPLICATION

The second application should be made directly after the petals have fallen. This application is also of value in the control of the common leaf spot[5] (frog-eye) and codling moth.

THIRD APPLICATION

Made 2 to 4 weeks after the petals have fallen, the third application is also of value in the control of leaf spot (frog-eye) and codling moth. If scab has been especially severe in previous years or the season has been particularly favorable to its development, an application 10 days to 2 weeks after the petals have fallen and another 4 weeks after the petals have fallen are desirable.

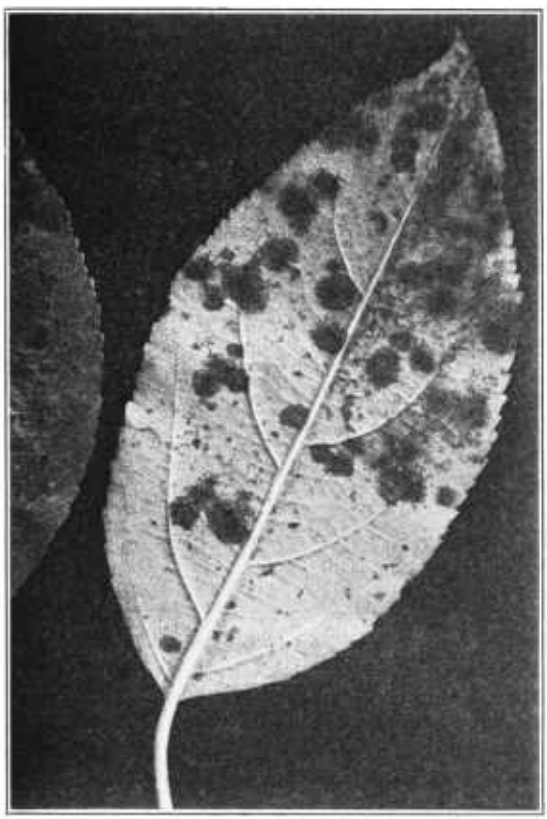

FIGURE 5.—Scab spots on the under side of an apple leaf.

If blotch[6] has been a serious disease, as it often is in the South and in the Middle West, bordeaux mixture should be used in place of the lime-sulphur solution, and the application should be made 2 weeks after the petals have fallen.

FOURTH APPLICATION

A fourth application should be made 8 to 10 weeks after the petals have fallen. If blotch or bitter rot[7] is to be controlled, bordeaux mixture should be used. Bordeaux mixture should be used in any event if the temperature is above 85° F., since it is less liable to cause injury in hot weather. This application constitutes the principal control measure for such minor diseases as sooty blotch[8] or cloud and Brooks fruit spot.[9]

Although the fourth application is often unnecessary for the control of scab, it should always be put on for the control of other diseases.

ADDITIONAL APPLICATIONS

In northern sections and in other sections in which scab is particularly destructive, the so-called "delayed dormant" application is often desirable. This

[5] Caused by the fungus *Sphaeropsis malorum* Pk.
[6] Caused by the fungus *Phyllosticta solitaria* Ell. and Ev. For methods of controlling blotch, see U. S. Department of Agriculture Farmers' Bulletin 1479, entitled "Apple Blotch."
[7] Caused by the fungus *Glomerella cingulata* (Ston.) Spauld. and Schrenk. For methods of controlling bitter rot, see U. S. Department of Agriculture Farmers' Bulletin 938, entitled "Apple Bitter-Rot and Its Control."
[8] Caused by the fungus *Glocodes pomigena* (Schw.) Colby.
[9] Caused by the fungus *Phoma pomi* Pass.

application should be made just as the tips of the leaves are appearing. Lime-sulphur solution, 1 gallon to 9 gallons of water, or bordeaux mixture 4–4–50, to which 3 percent oil emulsion is added, may be used. This application will also be effective against San Jose scale, and if nicotine sulphate, one-half pint to each 50 gallons of spray, is added, the spray will also be effective against aphids.

In northern sections winter apples may require an application about the middle of August, particularly if scab has not been well controlled earlier in the season. An application as late in the season as this may require that the fruit be washed to remove spray residues.

If apple blotch is present, a special application of bordeaux mixture should be made about 5 weeks after petal fall. If bitter rot is present, besides these 5 applications, 2 to 3 additional applications of bordeaux mixture at 2- to 3-week intervals are necessary.

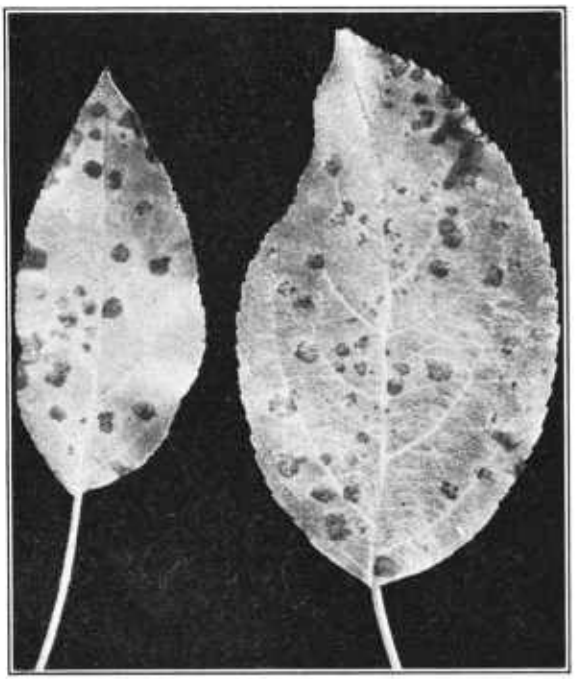

FIGURE 6.—Scab spots on the upper side of an apple leaf.

Bordeaux mixture should never be used in the first and second applications, because of the risk of severe injury to both fruit and foliage. It should be used in the third application only when it is necessary to control blotch, and when it is so used, care should be taken not to overspray the trees. If guns are used, special care should be taken. The spreaders which are often recommended for use with sprays have not proved especially beneficial in any of the writers' experiments in scab control. Casein, rosin-fishoil soap, and oil-emusion spreaders, however, can be sometimes used to advantage in applications for the control of bitter rot. For those desiring to use a spreader with the dilute lime-sulphur solution the commercial casein-lime powders at the rate of one-half pound to each 50 gallons of spray are recommended.

There are on the market a number of preparations consisting of colloidal sulphur or of finely divided sulphur to which a colloid has been added. These preparations in their present development are as a class not as efficient in the control of scab as the lime-sulphur solution. They are, however, less likely to cause injury, and they show promise of being useful, especially in sections where scab is not severe or on varieties not very susceptible to the disease.

If scab has been kept under control by the earlier applications, and blotch and bitter rot are not factors, it may be desirable to lessen the risk of spray injury by switching to one of these sulphurs in the third application, and possibly in the fourth if the weather remains cool.

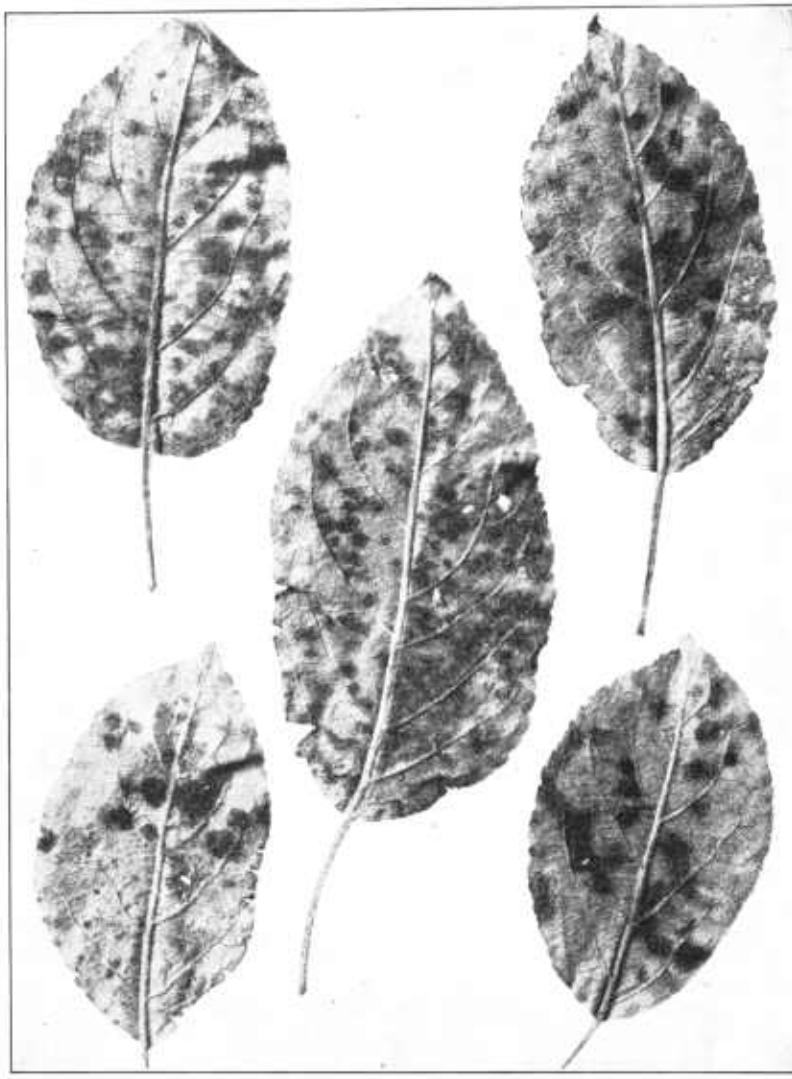

FIGURE 7.—Less clearly defined spots of scab on apple leaves.

DUSTING

None of the dusts so far in use are as efficient as dilute lime-sulphur in the control of scab. Dusting, however, is saving of labor and can be done rapidly. Furthermore, a power duster can be operated on soil so soft that a power sprayer could not be pulled over it.

Under such conditions dusting could supplement spraying. It should be remembered, however, that dust does not stick well and is not nearly so efficient as the liquid spray. For those who wish to dust, a mixture composed of 80 percent finely ground sulphur (dusting sulphur), 10 percent hydrated lime, and 10 percent arsenate of lead [10] is recommended. The common leaf spot (frog-eye) disease, blotch, and bitter rot are not controlled by the dusts now on the market. Dusting for the control of apple scab in New York is recommended by the Cornell Agricultural Experiment Station.

LIME-SULPHUR SOLUTION

Concentrated lime-sulphur (32° to 34° Baumé) made up and ready for dilution may be obtained from dealers in spray supplies. For use on apple trees during the growing season it should be diluted at the rate of 1¼ gallons to 50 gallons of water. A lime and sulphur preparation in dry form may be obtained, but care should be taken to see that it is such a product and not some other preparation. According to the reports of analyses and claims of manufacturers these dry lime and sulphur products contain about 70 percent calcium polysulphide. A preparation containing this percentage of calcium polysulphide should be used at the rate of 5 pounds for each 50 gallons of water to make a solution approximately equal to the concentrated solution diluted at the rate of 1¼ gallons to 50 gallons of water. Manufacturers of the dry product have usually recommended too weak a solution for the best results.

For immediate use a dilute lime-sulphur solution of proper strength for scab control can be prepared according to the following formula:

Stone lime (quicklime)	2 pounds.
Sulphur, commercial flour or flowers	4 pounds.
Water, to make	50 gallons.

An iron kettle or similar vessel raised on bricks or stones so that a fire can be built under it should be provided. After a fire has been started under the vessel containing a small quantity of water, the lime should be dumped in and if necessary enough additional water poured in to slake it. The sulphur should be screened, to break up the lumps, and added to the mixture, together with enough water from time to time to make a thin mixture that can be easily stirred. Boiling with occasional stirring should continue for about 45 minutes, which approximates the time necessary for the lime and sulphur to unite and go into solution. More water should then be added to cool the solution so that it can be handled. It is then ready to be passed through a strainer into the spray tank, which should contain enough water to make the total quantity of spray 50 gallons. The formula, of course, can be used to make up proportionately larger or smaller quantities, if desired. High-grade lime is necessary, free from calcium carbonate (air-slaked lime) and magnesium compounds, which form an insoluble sludge in the final product. If stone lime is not obtainable, hydrated lime may be used at the rate of one-third more. When hydrated lime is used the heat of slaking will, of course, be lacking, but the procedure

[10] See remarks concerning removal of spray residue, p. 5.

is the same. Commercial growers requiring large quantities of lime-sulphur solution are referred to United States Department of Agriculture Farmers' Bulletin No. 1285, entitled "Lime-Sulphur Concentrate", which furnishes information on the making of the concentrated solution on a large scale.

BORDEAUX MIXTURE

Except in orchards where blotch (not sooty blotch) is prevalent, bordeaux mixture should not be used in spring applications for the control of scab. Even when blotch is present bordeaux mixture should not be used until 2 weeks after petal fall (the third application in the schedule). Bordeaux mixture for use on apples usually contains 4 pounds of bluestone (copper sulphate) and 4 pounds of quicklime or 6 pounds of hydrated lime to each 50 gallons of water. In the third application of the schedule, however, the quantity of bluestone should be reduced to 3 pounds. If blotch and bitter rot are not factors, it may be reduced to 2 pounds. If the lime used is of poor quality and does not slake readily, 5 or 6 pounds should be used in all applications of bordeaux mixture.

The directions here given are for quicklime, or stone lime. If hydrated lime is used the quantity should be increased one-third. As hydrated lime is already slaked, it is ready for the required quantity of water to be added to it, as set forth in these directions:

To make a single barrel (50 gallons) of bordeaux mixture, dissolve the bluestone in 25 gallons of water, and in a separate barrel slake the lime and dilute it to 25 gallons. Then pour the contents of the two barrels simultaneously through a strainer into the spray tank.

If large quantities are to be used, a stock solution of the bluestone and a stock milk of lime should be prepared in order to save time.

A stock solution of bluestone may be made by dissolving it at the rate of 1 pound to each gallon of water. Fill a 50-gallon barrel two-thirds or three-fourths full of water, and place a sack (or a box with perforations in the bottom and sides) containing 50 pounds of bluestone in the upper part of the barrel, suspending it by a string or copper wire. In from 12 to 24 hours the bluestone will have entirely dissolved, when the sack or box should be removed and enough water added to fill the barrel. Time may be saved by using hot water, in which the bluestone will dissolve in a few minutes. After stirring, the solution is ready for use.

A stock milk of lime may be prepared by slaking 50 pounds of stone lime in a barrel or other vessel and finally adding water to make 50 gallons. In slaking the lime sufficient water should be used to prevent burning but not enough to "drown" it. The water should be added a little at a time and the mixture stirred to the bottom until the slaking is nearly completed. Sufficient water should then be added to leave a paste when the slaking is finished. Water to make the 50 gallons may then be added when desired.

Bordeaux mixture is easily made if a power sprayer with a good agitator is at hand. Fill the tank with water until there is room for only the required quantities of the stock fluids. Then, starting the engine (and accordingly the agitator), put in the stock bluestone solution and slowly add the stock milk of lime. For example, if

the tank holds 200 gallons, fill with water to about the 160-gallon mark and then, starting the engine, slowly add the 16 gallons of stock bluestone solution if the 4–4–50 formula is to be followed and afterward the 16 gallons of stock milk of lime. Allow the engine to run for a few minutes after both fluids have been added. Add more water, if necessary, to fill the tank. By this method an elevated platform is not needed, especially if an efficient mechanical tank filler is at hand.

For those not possessing power sprayers the following directions are given:

Take the necessary quantities of the stock copper sulphate solution and the stock milk of lime and place them in separate elevated dilution tanks, each of which should hold half as much as the total capacity of the spray tank. Thus, if the spray tank holds 200 gallons each dilution tank should hold 100 gallons, and, according to the 4–4–50 formula, 16 pounds of copper sulphate (16 gallons of the stock solution) and 16 pounds of lime (16 gallons of stock milk of lime) would be required. To each dilution tank add water (nearly half the total quantity of spray), and, after stirring, allow the diluted ingredients to run simultaneously through a strainer into the spray tank from separate hose or troughs attached to faucets near the bottom of each dilution tank.

The so-called "instant" bordeaux mixture is easily made, if a power sprayer with a good agitator is at hand. In the preparation of this mixture a powdered bluestone that dissolves quickly in water is used. It may be dissolved while the tank is being filled by placing the required quantity in a cloth sack suspended within the tank so that the inflowing water will wash through it. This may be accomplished by inserting the end of the intake hose in the open end of the sack. When the tank is about three-fourths full, and all the bluestone is dissolved, the engine should be started, to operate the agitator. Then the milk of lime, made from either stone lime or hydrated lime, should be added slowly while the filling of the tank is completed. Hydrated lime in a dry state is sometimes used, but a better product is made if it is first mixed with enough water to make it pour easily and then allowed to stand for a few hours before being used.

Only the quantity which can be used immediately should be prepared, as bordeaux mixture deteriorates on standing. Granulated sugar at the rate of 2 teaspoonfuls for each 50 gallons, dissolved in a little water and added to the mixture, has been recommended for retarding the rate of deterioration.

When arsenicals or other insecticides are to be used with bordeaux mixture and are mixed with water before being added to the spray tank, allowance should be made for these by leaving out the corresponding quantity of water from the quantities specified.

There are on the market a number of commercial bordeaux mixtures which are ready for use when mixed with water. These are usually sold under proprietary trade names. Growers interested in these preparations should consult United States Department of Agriculture Farmers' Bulletin No. 994, entitled "Commercial Bordeaux Mixtures: How to Calculate their Values."

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